DataPrivacyBR Research

Digital Public Infrastructures & Digital Public Goods for Combating Climate Change:

The Brazil Case Study

Revision **Pedro Saliba**
Mariana Rielli

Authorship **Rodrigo Duarte**

Translation **Beatriz L. M. Nunes**

Data Privacy Brasil is an organization that was born from the union between a school and a civil association to promote a culture of data protection and digital rights in Brazil and around the world.

Founded in 2018, Data Privacy Brasil Ensino emerged as a space to disseminate and innovate knowledge about privacy and data protection in the country. With content adapted to a more practical language, with exercises and case studies, this is a school for all those who are interested and want to delve deeper into the rich themes of privacy, data protection and new technologies.

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Directors
Bruno Bioni, Mariana Rielli and Rafael Zanatta

Coordination
Carla Rodrigues, Jaqueline Pigatto, Pedro Martins, Pedro Saliba and Victor Barcellos

Team
Alicia Lobato, Eduarda Costa, Eduardo Mendonça, Gabriela Vergili, Isabela Gomes, Isabelle Santos, Johanna Monagreda, João Paulo Vicente, Júlia Mendonça, Louise Karczeski, Matheus Arcanjo, Mekebib Assefa, Nathan Paschoalini, Otávio Almeida, Pedro Henrique, Rafael Guimarães, Rafael Regatieri, Rennan Willian, Roberto Junior, Rodrigo Duarte Guedes, Rodolfo Rodrigues and Vinicius Silva.

Press
For clarifications about the document and interviews, please contact us via email at imprensa@dataprivacybr.org

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Executive Summary

This report, funded by the Digital Public Goods Alliance (DPGA), explores the integration and use of digital public goods (DPG) for building digital public infrastructure that operates in the public interest, and more specifically as tools for addressing climate change. DPGs play a unique role in advancing the public interest, going beyond open-source technologies by including detailed documentation along with open licensing, which makes them easier to reuse. To be recognized as a DPG, a solution must also contribute to one or more Sustainable Development Goals, and its maintainers must demonstrate actions taken to minimize the risk of harm.

We are focusing the report's recommendations on actions that can be taken by Brazil, considering Brazil's leadership in the G20 in 2024 and the hosting of COP30 in 2025, but the report also contextualizes the global importance of the topic, mentioning India's G20 presidency in 2023, which encouraged multi-sectoral cooperation in the development of DPI and the UN's Global Digital Compact, an annex to the Pact of the Future which recognized the importance of both DPGs and DPI for digital transformation and innovation. The recommendations and analysis within this report are based on articles, reports, and interviews, highlighting the features and potential of DPI and DPGs.

Two Brazilian initiatives are used as examples: the Cadastro Ambiental Rural (CAR), which can be classified as a DPI, and the Projeto de Mapeamento Anual da Cobertura do Solo no Brasil (MapBiomas), which has characteristics of a DPG, such as the use of open licenses. We also provide examples of other digital public goods and their potential uses for enabling countries to build safe, inclusive and interoperable DPI, and more specifically for combating climate change.

This report seeks to move the narrative beyond physical infrastructure by bringing attention to potentially transformative new solutions and services enabled by secure flows of data across interoperable digital components. Our analysis shows how DPGs are relevant to the Sustainable Development Goals, transparently built, well documented, and can interoperate with other digital solutions, meaning that they can help advance digital transformation. We therefore conclude that DPGs can be important for Brazil's domestic and international agendas of advancing inclusive DPI that operates in the public interest and of scaling up the fight against climate change, and that they can also benefit countries outside of Brazil.

Introduction

From December 2022 to November 2023, India held the presidency position of the G20, an international cooperation forum which aims to shape and strengthen global economic issues. Building on years of growing interest, digital public infrastructure (DPI) became a key topic in the action plan presented to accelerate progress on the Sustainable Development Goals (SDGs).

Upon taking on the presidency in 2024, Brazil listed the fight against hunger, poverty and inequality as its main areas of concern, linking them to sustainable development and the restructuring of global governance. The inclusive digital transformation agenda permeates various working groups, reflecting the country's extensive experience in digital public services. The topic of DPI remains in close dialogue with the debates of the Indian presidency, especially based on Brazil's experiences with DPI, specifically digital identity (gov.br) and instant financial transactions (PIX).

In view of the 30th UN Climate Change Conference (COP30), which will be held in 2025 in Belém do Pará, right in the heart of the Amazon, Brazil is making an effort to use the G20 to demonstrate how it has tackled deforestation of biomes. The combination of environmental preservation and digital transformation gives Brazil a powerful and scalable approach for combating climate change, especially by showcasing platforms capable of processing data to support public policies. The fight against climate change is critical to a number of different priorities as it directly impacts issues such as social inequality, hunger, and poverty. Studies suggest that the primary victims are people in vulnerable situations, especially children and women[1], with the potential for an increase in crime in the affected regions[2].

The use of digital tools is essential for advancing these priorities and should be applied to enhance the efficiency of public policies on a global scale. With the adoption of the Pact of the Future with its annexed Global Digital Compact by UN Member Countries on September 22nd, the concepts of DPI and digital public goods (DPGs) were confirmed as central both to the global digitalization agenda in general and for advancing the Sustainable Development Goals (SDGs) in particular.

This report examines both Brazilian and international cases to illustrate the integration and use of DPGs for building DPI that operates in the public interest, and more specifically as tools for addressing climate change. The first case, Cadas-

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1 https://www.unicef.org/rosa/blog/climate-changes-greatest-victims-are-women-and-girls Accessed on: October 17, 2024.

2 https://igarape.org.br/en/climate-change-and-crime-in-cities/ Accessed on: October 17, 2024.

tro Ambiental Rural (CAR), is already operational and has over 7 million records of rural lands in Brazil. It is currently undergoing a series of changes that will evolve the system into more of a digital public infrastructure that enables better services across multiple sectors and domains. Meanwhile, the following existing and potential DPGs will be highlighted for their relevance for climate action in Brazil and beyond: CKAN[3]; the Geospatial Hand-in-Hand Platform[4]; Sentinel[5] and the Projeto de Mapeamento Anual da Cobertura do Solo no Brasil (MapBiomas), a Brazilian third-sector initiative known for its transparency measures and relevance in biome preservation.

This research was based on theoretical references on the topics, as well as interviews conducted with experts in July 2024. The goal was to provide more understanding to how Brazil can combine its environmental preservation and digital transformation agendas to more effectively combat climate change. In the research we explore the nuanced debate around DPI, and how taking a DPI-approach can help Brazil to not only scale up climate action and combine environmental preservation objectives with other objectives such as financial inclusion and trade, but also promote a public debate on commitments and responsibilities. We discuss how interoperability, transparency, sustainability and governance are essential for ensuring these digital transformation efforts serve the public interest, and how using digital public goods can help Brazil and other countries achieve these objectives.

The first chapter briefly introduces the concepts, so as to situate the reader in the incipient debate. Next, we present the Rural Environmental Registry and MapBiomas, their resources, strengths and limitations as they relate to the DPG and DPI concepts. We outline how building and sharing some CAR-components as digital public goods can both strengthen transparency, interoperability and their sustainability within the Brazilian context, while also allowing other countries to reuse those particular components. Finally, we explore instances where countries, including Brazil, could utilize existing digital public goods to enhance their efforts to fight against climate change through open data, transparency, and participatory governance.

We would like to thank the following people for their participation as interviewees: Cable Green, Henrique Dolabella, Francisco Gaetani, Jarlene Gomes, Julia Dias, Luísa Falcão, Reina Otsuka, Vijay Tyragi, Vijay Vujjini. Their comments have been incorporated throughout the text in an anonymized form, in order to base the debate on concrete experiences.

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3 https://app.digitalpublicgoods.net/a/11476. Accessed on: July 10, 2024.

4 https://www.fao.org/hih-geospatial-platform/en/. Accessed on: July 10, 2024.

5 https://www.arcgis.com/home/item.html?id=cfcb7609de5f478eb7666240902d4d3d. Accessed on: July 10, 2024.

Introducing the concepts of DPGs and DPI

When using online storage services, is our data stored in the cloud? This image of a data cloud is as interesting as that of flying cars, but both don't exist. Cars still need roads, just as online storage depends on physical servers to host the information, demonstrating how central infrastructures are, whether physical or digital. If in the past the state played a central role in building physical infrastructures, the advance of digitalization in all spheres of society also demands coordinated public action to ensure digitalization operates in the public interest.

Recently, there has been a steady increase in digitalization in both the private and governmental spheres, accentuated after Covid-19. This period has also seen the growing prominence of two relatively new terms. The first, which had existed in various forms for years, but was brought onto the international stage during India's G20 presidency in 2023, is DPI. What is digital public infrastructure? When we think of what DPI might be, we might think of building a digital highway as a network of interoperable systems components that facilitate secure data flows that can be brought together for holistic and privacy-protecting service delivery. These components and data flows enable public and private services that society has increasingly come to depend on, and the potential for continuous future evolution and innovation through their interoperability features. DPI-components include commonly cited Brazilian examples, like Pix, gov.br and My Digital SUS[6]. These components provide essential services to society, gaining momentum in the process of the digital transformation of the public sector as well as for the private sector.

The second concept is that of DPGs, adapted from mainstream economic theory on public goods. A pure public good is defined as "one in which, for all individuals in a given territory, there is no rivalry in consumption, and where exclusion is either not possible or, if possible, not desired" (Pereira, 2009, p. 4). Therefore, public goods are characterized by being non-rivalrous, indicating that one's consumption or usage does not limit or take away from someone else's, and non-excludable, meaning that you cannot prevent someone from using or consuming that good[7].

Digital public goods follow the same logic and the concept covers open-source software, open datasets, open artificial intelligence systems, and open content

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6 Platform for accessing digital health services from the Brazilian Public Health System, such as clinical history, vaccinations and exams. More on: https://www.gov.br/pt-br/servicos/acessar-a-plataforma-movel-de-servicos-digitais-do-ministerio-da-saude

7 More on: https://digitalpublicgoods.net/digital-public-goods/

collections, . What makes DPGs non-inclusive and non-rivalrous is first and foremost that they all have open-source licenses which makes them available for others to adopt and adapt to their specific contextual needs. But they go beyond traditional open-source technologies by also having documentation in addition to their open licensing that makes them easier to reuse. They furthermore have dimensions that make them particularly relevant for advancing the public interest: DPGs must be relevant for advancing one or more of the sustainable development goals[8], and DPG maintainers must show how DPGs have taken steps to minimize the risk of doing harm. Some examples of digital public goods are the Modular Open Source Identity Platform (MOSIP) software and the MET Norway Weather API. The former, which is used by many countries as part of building their DPI, enables the adoption of different modules that are necessary for implementing a basic digital identity system in a cost-effective way, while the latter provides an open global weather data interface, the data for which is produced by MET Norway. As a result of their open source nature, MOSIP and MET Norway can be accessed without impacting their general availability or excluding other users. Additionally, the modular nature of MOSIP allows countries to adopt the components that are most relevant to their particular needs, enabling integration with the system elements they may already have in place. This is particularly important when building DPI.

The digital transformation of the public sector reinforces the importance of state action in building digital infrastructures—just as physical infrastructures were built in the past. The state's effort in building public digital infrastructures is important because, otherwise, the functions of society may be under the exclusive ownership of private companies. In this scenario, state sovereignty is impacted, as is the capacity of public institutions to act for the public good (Eaves; Mazzucato; Vasconcelos, 2024, p. 21)

Added to this transformation is the change in perception of the potential of digital technologies. Eaves, Mazzucato and Vasconcellos (2024, p. 4) point out that for decades the advance of digitalization has been associated with the construction of software and platforms for specific public and private needs, as well as the use of data for more assertive decisions. Today, however, there is concern about how this data is processed, where it is stored and what risks associated with digital infrastructure could impact national public policies. In this sense, DPI emerges as a call to action, in order to build a digital environment that is suited to today's geopolitical realities and that serves the public interest..

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8 The Sustainable Development Goals (SDGs) are a global agenda composed of 17 ambitious objectives and 169 interconnected targets that address the main development challenges. This agenda was adopted during the United Nations Sustainable Development Summit in 2015, and its objectives and targets are to be achieved by 2030. The SDGs aim for actions to end poverty, protect the environment and climate, ensuring that people everywhere can enjoy peace and prosperity.

The construction of public digital infrastructures must include an understanding of intentionality and that such developments are not neutral. For example, when we think back to the construction of roads by the government, the explicit intention was to connect two points: this choice involves variables such as population, production flow and its economic impacts. Even so, there is no shortage of cases in which public investment in traditional infrastructure has resulted in private benefits that have come at the cost of the public interest, such as the concession of stretches of road for toll collection. This type of logic undermines the neutrality of the public good, as well as strengthening the road modal, to the detriment of other modes such as railroads or waterways.

The evolution of the digital sphere with various forms of hard infrastructure such as fiber optic cables, mobile towers and low-orbit satellites increasingly enabling internet connectivity and digital access even in areas that have previously been hard to reach with traditional infrastructure, makes it possible to completely reimagine public and private service delivery. We can imagine transformative new services enabled by secure flows of data across interoperable digital components that are potentially much cheaper to build and adapt than traditional physical infrastructure (for instance railroads or airports). However, the risks, for instance from monopoly structures and loss of sovereignty, are also correspondingly larger. We therefore argue that this digital transformation effort should be done by taking a DPI approach that serves the public interest.

DPI makes it possible to build solutions that prioritize the production of public value, being used in the financial area, for digital identity and, as we shall see, with the possibility of adding value in the fight against climate change. Its particularities can help solve development problems by facilitating access to essential services, especially if we think about how digital access can benefit populations further away from urban centers, mitigating financial costs and promoting access to different services. To ensure DPI serves the public interest, the construction of DPI must, however, explicitly prioritize the production of public value. To this end, Eaves et. al. (2024) state that it is necessary to observe and guarantee five points: the first refers to the goal and direction, i.e. determining an ambitious direction in which policies can be designed, public-private partnerships formed and citizens involved. The second covers the process of co-creation and participation, in which the rules and mechanisms for co-investment, collaboration and coordination involving a diverse group of social actors must be established. The third deals with collective learning and the sharing of knowledge. It is necessary to rethink institutional practices so that they support collective learning and act to develop long-term capacities and competences. The fourth addresses access for all and benefit sharing, ensuring that public value is distributed equitably, aimed

at inclusive growth. Finally, the fifth covers transparency and accountability, with the aim of gaining and maintaining the trust of citizens by monitoring progress in practical actions that demonstrate this commitment.

Proposals anchored in transparency measures, such as open source technologies and governance with public participation, tend to bring long-term benefits, including different stakeholders to promote digital policy. DPGs are therefore highly relevant to the discussion of how Brazil and other countries can take a DPI approach that serves the public interest. DPGs can help countries build DPI more cost effectively and with more local ownership and co-design, while ensuring interoperability with existing solutions. DPGs can also enable learnings, best practice exchanges and collaboration across countries, without diminishing their digital sovereignty.

Approaches to defining and understanding the concept of digital public infrastructure (DPI)

In recent years, there has been a growing demand for governments to act in digital services, requiring the construction of systems that make it possible to coordinate actions such as distributing vaccines, distributing subsidies or grants to tackle climate change, and managing digital identities so that they can enable inclusive access to services, among other actions. The recent Covid-19 pandemic exemplifies the importance of building and using digital public infrastructures: the imposition of social isolation has required various fronts of public services to be digitized, with specific security measures for data processing in this area.

Eaves, Mazzucato and Vasconcellos (2024, p. 6) once again define infrastructure as the use of shared resources for multiple purposes. Based on this understanding, the authors point out that three parameters must be met in order to be considered infrastructure. The first refers to the characteristic of non-rivalry, i.e. the resource can be used for different purposes without impacting its availability. The second points out that social demand for the resource is primarily oriented towards productive activities where infrastructure is used as a factor of production. Finally, the third covers its use as a factor of production for a multiplicity of goods and services, whether public, private or social. The internet is used as an example to highlight how the union of software through protocols and hardware through servers constitutes a digital infrastructure. It is also valid to say that the internet is a shared medium for different purposes.

Having briefly reviewed the role of the State and the definition of infrastructure, it is important to point out that there is still no exact definition of what digital public infrastructure is. Therefore, the purpose of this article is to discuss some of the common concepts, highlighting their central points of agreement on what DPI is.

During India's chairmanship in 2023, the G20 outlined a definition of DPI, highlighting that digital public infrastructure is:

> Under the Indian Presidency's initiative, we recognize that digital public infrastructure, hereinafter referred to as DPI, is described as a set of shared digital systems that should be secure and interoperable, and can be built on open standards and specifications to deliver and provide equitable access to public and/or private services at societal scale and are governed by applicable legal frameworks and enabling rules to drive development, inclusion, innovation, trust, and competition and respect human rights and fundamental freedom.

This contribution from India's G20 chairmanship was based on a review of different conceptions from the World Bank, CDPI, DIAL, DPGA, OECD, Co-Develop, GovStack[9] and other organizations. In its 2022 document[10], the World Bank highlights the recognition of DPIs as "rails" used to provide services by the public and private sectors. This alludes to the role of supporting these infrastructures for digital services that enable transactions and connections between people, companies and governments (Almeida; Martins, 2024).

India's chairmanship of the G20 also produced the document "The DPI Approach. A Playbook"[11], designed to provide a practical overview of DPI so that countries can adapt it to their respective contexts and objectives. We highlight in the table below the points relating to each aspect of DPI highlighted in the Playbook.

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9 These organizations have in common the pursuit of development with a recent emphasis on accelerating the adoption of digital public infrastructures. Centre for Digital Public Infrastructure (CPDI) <https://cdpi.dev/>; Digital Impact Alliance (DIAL) <https://dial.global/work/govstack/>; Digital Public Goods Alliance (DPGA) <https://digitalpublicgoods.net/>; OECD (Organization for Economic Co-operation and Development) <https://www.oecd.org/en.html>; Co-Develop <https://www.codevelop.fund/who>; and GovStack <https://www.govstack.global/ >.

10 WORLD BANK. ID4D. A Digital Stack for Transforming Service Delivery: ID, Payments, and Data Sharing. 2 Feb. 2022. Available at: <https://documents1.worldbank.org/curated/en/099755004072288910/pdf/P1715920edb5990d60b83e037f756213782.pdf>. Accessed on: July 10, 2024.

11 UNPD. G20. The DPI Approach: A Playbook. 2023. Available at: <https://www.undp.org/sites/g/files/zskgke326/files/2023-08/undp-the-dpi-approach-a-playbook.pdf>. Accessed on: June 19, 2024.

Table 1 - Digital Public Infrastructure

Terms	Context
Infrastructure	Enabler for national scale innovation: acts as building blocks for large-scale development of digital solutions.
	Ecosystem-led implementation: DPI can be private-sector led, public-private led, or public-sector led.
	Ecosystem-level impact: can be leveraged in public and private domains.
Public	Public governance and accountability to people.
	For public interest.
	Government orchestration.
Digital	Digital railroads.
	Enables remote, paperless, presence-less service delivery.
	Reducing cost and increasing access through digital.

Source: The DPI Approach. A playbook. 2023, p. 4

Another definition is proposed in the 2022 document “GovStack Definitions: Understanding the Relationship between Digital Public Infrastructure, Building Blocks & Digital Public Goods”[12]. Digital public infrastructure is presented more broadly as a solution composed of digital building blocks that enable both the public and private sectors to offer functions and services to society as a whole. Within this scope, services such as digital forms of verifiable identification, real-time payment, and secure data and information exchange systems can be offered to different sectors. Their uses are tailored to the needs of each country, and there is great potential for innovation in the area, with new functionalities being developed in different public policies. Another point of this document is that countries can use both proprietary and open source solutions (including DPGs) as building blocks for developing their DPI.

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12 Digital Public Goods Alliance. GovStack Community of Practice. GovStack Definitions: Understanding the Relationship between Digital Public Infrastructure, Building Blocks & Digital Public Goods. May 2022. Available at: <https://digitalpublicgoods.net/DPI-DPG-BB-Definitions.pdf>. Accessed on: June 18, 2024.

The United Nations, largely aligned with the definitions of recent G20 presidencies, has been building an additional level of consensus on DPI, indicating that it should be composed of open technology and interoperable with transparent, accountable, and participatory governance interfaces to enable innovation and the development of social value (Almeida; Martins, 2024). The Global Digital Compact was adopted by UN Member States on September 22nd, 2024, with significant references to both digital public infrastructure and digital public goods.

Functions such as real-time payments, verifiable identity, and real-time data sharing have emerged as the most essential components of DPI to date and are, as such, are establishing themselves as indispensable tools for multiple sectors, serving as a foundation for achieving the sustainable development goals[13].

Almeida and Martins (2024) mention Brazil's stance in the debate on DPI and the search for pillars that point to the central elements for understanding this infrastructure. In 2024, Brazil took over the chairmanship of the G20 and its strategy continued the debates on the premises of digital public infrastructure, adding discussions on development, as well as the publication of Decree No. 12.069, of June 21, 2024[14], which provides a definition of DPI in the context of the National Digital Government Strategy. The decree recognizes DPI as a comprehensive solution both in its universal scale and in the participation of different actors:

> Article 4º, III: Digital public infrastructures - DPIs: structuring solutions, transversal to various public policies, which adopt network technology standards built for the public interest, which allow universal scale, and enable the orchestration of uses by various players, from the public and private sectors, in an integrated manner in physical and digital channels, governed by applicable legal frameworks and enabling rules to promote development, inclusion, innovation, trust, competition, respect for human rights and individual freedoms. (Brasil, 2024)

Reflecting the growing global interest in digital public infrastructure, the 50-in-5 campaign was launched in November 2023 to bring together 50 countries committed to building safe, inclusive, and interoperable components to implement components of their DPI over the following five years. The Digital Public Goods Alliance (DPGA) plays a key role in facilitating this effort alongside Co-Develop, as the campaign's coordinators. Countries at different stages of digital trans-

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13 The UN's Global Digital Compact is a comprehensive framework for digital governance and AI, and can contribute with the understanding of the potentials and risks of these technologies. Full text here: https://www.un.org/global-digital-compact/sites/default/files/2024-09/Global%20Digital%20Compact%20-%20English_0.pdf . Accessed on: October 17, 2024.

14 BRAZIL. Presidency of Brazil. Decree No. 12.069, of June 21, 2024. 2024. Available at: <https://www.planalto.gov.br/ccivil_03/_Ato2023-2026/2024/Decreto/D12069.htm>. Accessed on: July 20, 2024.

formation, regardless of income level or geography, participate in 50-in-5 by sharing DPI knowledge and solutions - including digital public goods, ensuring that no countries have to undertake DPI implementation alone. Brazil joined the campaign in September 2024, demonstrating its commitment to advancing its DPI and cooperating with other countries on similar efforts.

Digital Public Goods

Digital transformation impacts societies in general and governments in particular, demanding the construction of digital governmental services. The previous section outlined various approaches to understanding and defining DPI that operates in the public interest. Digital public goods are open-source solutions that can be used by countries to build DPI, such as the digital identity system, real-time payments and secure data exchange, but DPGs can also be more sector or domain-specific, such as vaccine certification systems, weather forecasting algorithms or data, or high-resolution satellite imagery covering tropical rainforests.

Digital public goods have open source code and good documentation of how they have been built - including how they have been designed to reduce the risk of doing harm. As they are built with openness as a core principle, their use enhances transparency and social participation in how countries implement DPI. The option to explore DPGs in public services allows governments to improve digital interoperability, social participation and digital transformation through the opportunity to freely explore the software, and the possibility for multiple stakeholders to contribute to the implementation process[15]. In this section, we will examine DPGs and their impact on the digital transformation of governments, including the growing country demand for adopting DPGs for building DPI and for taking climate action.

The issue of digital cooperation was the subject of a High-Level Panel of the Secretary-General of the United Nations[16] in 2018, whose aim was to put forward proposals to strengthen cooperation in the digital environment between governments, the private sector, civil society, international organizations, academic institutions, the technical community and other relevant stakeholders. Among the recommendations submitted by the panel was the proposal to form an alliance and platform to support DPGs[17]. This led to the creation of the multi-stakeholder Digital Public Goods Alliance (DPGA)[18] initiative in 2019, which aims to accelerate the achievement of the sustainable development goals through the discovery, development, use and investment in digital public goods. Today, the DPGA has over 40 members, including governments and their agencies, multilateral orga-

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15 Appendix I contains a table summarizing the definitions for easier understanding.

16 United Nations. Secretary-General's High-Level Panel on Digital Cooperation. 2018. Available at: <https://www.un.org/en/sg-digital-cooperation-panel>. Accessed on: July 19, 2024.

17 United Nations. Secretary-General's High-Level Panel on Digital Cooperation. The Age of Digital Interdependence. 2019. Available at: <https://www.un.org/en/pdfs/HLP%20on%20Digital%20Cooperation%20Report%20Executive%20Summary%20-%20ENG.pdf>. Accessed on: July 19, 2024.

18 Digital Public Goods Alliance. Unlocking the potential of open-source technologies for a more equitable world. Available at: https://digitalpublicgoods.net/

nizations like UN entities, philanthropic foundations, funders, think tanks, and technology companies. Over a dozen countries are members, including Norway, Singapore, Ethiopia, as well as Guatemala, the Dominican Republic, ITS Rio, and the Inter-American Development Bank from the Latin American and Caribbean region. With growing demand from the region, more countries from LAC are expected to join. Through the DPGA, members collaborate to create a thriving global ecosystem for digital public goods and contribute to achieving the SDGs.

The Digital Public Good Alliance Secretariat leads the creation and maintenance of foundational components vital to the DPG ecosystem and plays a central role in the international digital cooperation ecosystem. For instance the DPGA Secretariat leads the operationalization of the definition from the UN Secretary-General's Roadmap for Digital Cooperation, which defines DPGs as open-source software, open standards, open data, open AI models, and open content that respect privacy, applicable laws, and best practices, do no harm, and help achieve the SDGs. Based on this definition, the DPGA Secretariat has established the DPG Standard, which is the nine indicators that determine whether software, data, AI systems, and/or content can be recognized as digital public goods. Once a solution is recognized as a digital public good, it is listed on the DPG Registry. The DPGA Secretariat manages both the DPG Standard and maintains the DPG Registry which allows for individuals to access and discover digital public goods. The table below presents the requirements for a solution to be recognized as considered a DPG.

Table 2 - DPG Standard, requirements for recognizing a digital solution as a DPG

Indicator	Requirement
1. Relevance to Sustainable Development Goals	Digital public goods must demonstrate relevance to advancing the Sustainable Development Goals (SDGs).
2. Use of Approved Open Licenses	Digital public goods must demonstrate the use of an approved open license. For open-source software, only Open Source Initiative (OSI) approved licenses are accepted19. For open content collections the use of a Creative Commons license20 is required. DPGs are encouraged to use a license that allows for both derivatives and commercial reuse (CC-BY and CC-BY-SA) or dedicate content to the public domain (CC0); licenses that do not allow for commercial reuse (CC-BY-NC and CC-BY-NC-SA) are also accepted. For open data, an Open Data Commons21 approved license is required.
3. Clear Ownership	Ownership of assets that the digital public good produces must be clearly defined and documented. For example, through copyright, trademark or other publicly available information.
4. Platform independence	When the digital public good has mandatory dependencies that create more restrictions than the original license, proving independence from the closed component(s) and/or indicating the existence of functional, open alternatives that can be used without significant changes to the core product is required.
5. Documentation	Digital public goods require documentation of the source code, use cases, and/or functional requirements. For content collections, this should include all relevant/compatible apps, software, or hardware required to access the content collection, and instructions regarding how to use it. For software solutions, this should be technical documentation that would allow a technical person unfamiliar with the project to launch and run the software. For data projects, this should be documentation that describes all the fields in the set, and provides context on how the dataset was collected, and how it should be interpreted.
6. Mechanism for Extracting Data	Digital public goods with non-personally identifiable information (PII) design for possibility of extracting or importing non-PII data and content from the system in a non-proprietary format.
7. Adherence to Privacy and Applicable Laws	Digital public goods must be designed and developed to comply with privacy and other applicable laws.
8. Adherence to Standards & Best Practices	Digital public goods must be designed and developed to align with relevant standards, best practices, and/or principles. For example, the Principles for Digital Development22.

19 Open Source Initiative. OSI Approved Licenses. Available at: https://opensource.org/licenses.

20 Creative Commons. Licenses List. Available at: https://creativecommons.org/licenses/.

21 Open Knowledge. Open Definition. Available at: https://opendefinition.org/licenses/.

22 Principles for Digital Development. Available at: https://digitalprinciples.org/principles/.

9. Do No Harm by Design	Digital public goods must be designed to anticipate, prevent, and do no harm by design.
9.a) Data Privacy & Security	Digital public goods that collect, store and distribute personally identifiable data, must demonstrate how they ensure the privacy, security and integrity of this data in addition to the steps taken to prevent adverse impacts resulting from its collection, storage and distribution.
9.b) Inappropriate & Illegal Content	Digital public goods that collect, store or distribute content must have policies identifying inappropriate and illegal content such as child sexual abuse materials in addition to processes for detecting, moderating, reporting and removing inappropriate/ illegal content.
9.c) Protection from Harassment	If the digital public good facilitates interactions with or between users or contributors there must be a process for users and contributors to protect themselves against grief, abuse, and harassment. The project must have system(s) to address the safety and security of underage users.

Source: Digital Public Goods Alliance. (2024). DPG Standard[23].

Finally, the document "Framework for Digital Public Goods in Least Developed Countries"[24] points out that DPGs can be a way of accelerating the development and expansion of digital platforms and applications, as well as fostering social and economic growth. As open solutions available for use according to the needs of each government, digital public goods become an efficient solution for promoting digital technologies in the public sector. Furthermore, their transparent nature enables social oversight, adaptability, and interoperability, fostering innovation among various interested stakeholders.

Below is a summary addressing the connection between digital public infrastructure and digital public goods, highlighting how both have the potential to contribute to Brazil's agendas in inclusive economic development and climate action.

DPIs consists of solutions and systems that enable the provision of digital services and functions for society as a whole. The most common components of DPIs are verifiable digital identity, real-time payments and secure data exchange.

DPGs are open source digital solutions that are relevant to the achievement of one or more of the Sustainable Development Goals. Their open source license means that they can be freely adopted and adapted to meet context-specific needs. DPGs can also be used to build digital public infrastructure (DPI) capacities (for example, MOSIP[25] is a DPG used as part of DPI efforts)

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23 Digital Public Goods Alliance. Digital Public Goods Standard. Available at: https://digitalpublicgoods.net/standard/. Accessed on September 13, 2024.

24 ABBASI, Salma; HAQUE JAMI, Rezwanul; JIISUN, Md Sahariar Hasan. "Framework for Digital Public Goods in Least Developed Countries", in Framework for Digital Public Goods in Least Developed Countries, vol., no., pp.1-15, 8 Sept. 2023, Doi: 10.1109/IEEESTD.2023.10247189. Available at: <https://ieeexplore.ieee.org/abstract/document/10247189/keywords#keywords> . Accessed on: June 20, 2024.

25 https://www.mosip.io/

There are also DPGs that are particularly relevant to enabling governments, civil society and other stakeholders to address climate change. These include satellite-based technologies to monitor tropical deforestation, open source weather forecasting models and open data to support climate change adaptation and disaster response, as well as digital solutions to improve energy efficiency and access.

We began this study by contextualizing the terms digital public infrastructure and digital public goods, highlighting general lines and concrete examples that help differentiate these two concepts and approaches, as well as how they (can) relate to each other. In the next section, we will focus on a specific area in which DPI and DPGs can promote sustainable development goals: environmental protection and combating climate change. On the one hand, they can serve as examples of policies and practices specific to Brazil that can inspire other countries in the application of DPG and DPI frameworks. On the other hand, the analysis can help Brazilian actors involved in the design and implementation of such programs by making these connections explicit, as well as where changes can be considered to improve their ability to meet sustainability and environmental protection goals through open standards, whether at the level of infrastructure or specific applications.

Rural Environmental Registry (CAR)

Climate change is becoming more tangible in reality, such as the recent rains in the south of Brazil[26] which, coupled with management errors, destroyed many localities. Locally and globally, events such as storms, windstorms, droughts, floods, landslides and forest fires are recurring more frequently.

Digitalization has brought data to the fore, opening up new avenues for data-driven decisions and improved artificial intelligence. The report Call for weather, climate & hydrological information datasets to be made open and freely available as digital public goods[27] prepared by the Digital Public Goods Alliance (DPGA), the International Telecommunication Union (ITU) and the World Meteorological Organization (WMO) highlights that in the field of climate change,access to high-quality data is an obstacle to decision-making, as both its availability and dissemination are limited.

There are examples in Brazil of how the datafication of territories, with a focus on environmental analysis, can bring greater assertiveness to decisions on climate change. One of these is the Rural Environmental Registry (CAR), a tool that brings together data on rural properties and incorporates environmental information. This database allows for use in control, monitoring, environmental and economic planning and in combating deforestation.

According to information from the gov.br portal, the Rural Environmental Registry (CAR) is a “nationwide electronic public registry, mandatory for all rural properties”[28]. Its purpose is to gather environmental information on rural properties and possessions to enable control, monitoring, environmental and economic planning and the fight against deforestation (Article 29 of Law No. 12.651/2012). The CAR was created by Law No. 12.651/2012, also known as the Forest Code, within the scope of the National Environmental Information System - SINIMA and regulated by MMA Normative Instruction No. 2 of May 5, 2014.

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26 In May 2024, the state of Rio Grande do Sul was the scene of one of the worst environmental disasters in Brazil’s recent history. In just over a week, a historic flood inundated entire towns, killing 146 people and affecting more than 2 million inhabitants. More information at: https://www.nytimes.com/2024/05/08/world/americas/brazil-flooding-photos.html

27 Call for weather, climate & hydrological information datasets to be made open and freely available as DPG. January 2022. Authored by: Digital Public Goods Alliance, International Telecommunications Union & World Meteorological Organization. Available at: https://digitalpublicgoods.net/DPGA-Climate_Change_Adaptation_Report.pdf. Accessed on: July 10, 2024.

28 Source: https://www.car.gov.br/#/sobre. Accessed on: 06 Aug. 2024.

The public registration in the CAR is the initial step for the rural property to be environmentally regular. It is done through an electronic registration with the competent state agency in which the property is located, informing:

> Information on the owner. Whether they are the rural owner or directly responsible for the rural property;
>
> Data on the documents proving ownership and/or possession; and
>
> Georeferenced information on the perimeter of the property. This includes areas of social interest and areas of public utility, with information on the location of remaining native vegetation, Permanent Preservation Areas, Restricted Use Areas, Consolidated Areas and Legal Reserves.

The Forest Code is the law that defines the rules for exploiting the country's vegetation. This legislation establishes, for example, areas that must be preserved and others that can be exploited. The first Forest Code dates back to 1934, with successive modifications that created percentages for legal reserves and permanent preservation areas. The various changes required discussion on implementing a new law, and after 12 years of debate between ruralists and environmentalists, the current legislation, Law No. 12.651/2012, was enacted. This new legislation modifies the legal regime for protecting vegetation in the country, with the Rural Environmental Registry (CAR) as the main instrument for implementing the new Forest Code.

Therefore, the CAR is consolidated as an instrument that integrates "geo-referenced environmental information[29] on rural properties and possessions, making up a database for control, monitoring, environmental and economic planning and combating deforestation" (PQGA/IBAM[30], p. 6), but it is not considered a title for recognizing the right of ownership or possession of rural property[31].

According to Gonçalves (2022, p. 25) the implementation of the CAR involves three central players. The first is the person who uses the land, i.e. "rural property owners, traditional peoples and land reform settlers" who are responsible for entering the data into the system. The second actor is the state or municipal public bodies, both of which are responsible for analyzing the registrations and approving

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29 Environmental Information: This is information that characterizes the perimeters and location of the remnants of native vegetation in Public Utility Areas, Permanent Preservation Areas (APP), Restricted Use Areas, Consolidated Areas and Legal Reserves (RL), as well as areas being recomposed, recovered, regenerated or compensated. Normative Instruction No. 02/2014 of the Ministry of Environment (PQGA/IBAM, p. 6).

30 Qualification Program: Environmental Management. Study Notebook. CAR - Rural Environmental Registry. Available at: https://www.amazonfund.gov.br/export/sites/default/pt/.galleries/documentos/acervo-projetos-cartilhas-outros/IBAM-CAR-caderno-estudo.pdf. Accessed on: Aug. 12, 2024.

31 Rural property: A continuous area, regardless of its location, which is or may be used for agricultural, livestock, plant extraction, forestry or agro-industrial exploitation. It is worth remembering that rural property can fall into different ownership situations such as private property; consolidated ownership; areas of common use; areas of traditional communities etc. (PQGA/IBAM, p. 6)

their location. Finally, there is the federal structure with the role of coordinating the implementation of the CAR, initially led by the Ministry of Environment (MMA) and later delegated to the Brazilian Forest Service (SFB).

The information declared in the CAR is managed through the Rural Environmental Registration System (SICAR). SICAR is a database platform at Federal level that condenses the information registered and recorded in the CAR. Gonçalves (2022, p. 17) highlights the specific objectives of SICAR, as set out in Article 3 of Decree No. 7,830/2021[32]:

> Receiving, managing and integrating CAR data from all federal entities; registering and controlling information on rural properties regarding their perimeter and location, remaining native vegetation, areas of social interest, areas of public utility, APP areas, UR areas, consolidated areas and RL; monitor the maintenance, restoration, regeneration, compensation and suppression of native vegetation and vegetation cover in APPs, URs and RLs within rural properties; promote environmental and economic planning of land use and environmental conservation in the national territory; and make public information available on the Internet about the environmental regularization of rural properties in the national territory. (Gonçalves, 2022, p. 17).

In order to achieve these objectives, data collection in SICAR is carried out using a program available on the CAR website[33], for use on computers. The options available to users are: download images, where it is possible to obtain satellite images of a given municipality; register, an option that opens up fields for registering properties and viewing them; record for sending, where it is possible to record property registrations, generating files (.car) for sending and also viewing registrations that have already been recorded; send, where it is possible to send files (.car) of registered and recorded properties; and rectify, where it is possible to change a property registration that has already been finalized.

The registration of information in the CAR program is legally based on Decree No. 7,830/2012 and MMA Normative Instruction No. 2, covering the fields shown in the table below:

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32 BRAZIL. Decree No. 7.830, of October 17, 2012. Available at: <https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/decreto/d7830.htm>. Accessed on: Aug. 15, 2024.

33 GOB.BR. Environmental Regularization - Rural Environmental Registry (CAR). Available at: https://www.car.gov.br/#/baixar. Accessed on: Aug. 16 2024.

Table 3 - Rural property registration system tabs

Field	Description
Registrant	Name, Individual Taxpayer Identification Number, date of birth and the name of the mother of the person responsible for registering the property. At this stage, you have the option of appointing a representative to carry out the registration;
Real estate	Name of the property, state, municipality, zip code, description of access to the property, mailing address, e-mail address and contact telephone number;
Domain	Data on the owner, rural possessor or person directly responsible for the rural property: name, Individual Taxpayer Identification Number, date of birth and mother's name. Company data can also be entered in this field, such as company name and Corporate Taxpayer Identification Number, if they own the registered property;
Documentation	Name of the property, area, type of document (deed, purchase and sale contract, in regularization, registration certificate, immittance of possession); registration number of the document, date, book, sheet, federal unit of the notary's office, municipality of the notary's office, code in the National Rural Registry System, certification of the property at Incra, Property Registration Number at the Federal Revenue Office (NIRF);
Geo	The respective georeferenced plan of the perimeter of the property, areas of social interest and areas of public utility, with information on the location of the remaining native vegetation, Permanent Preservation Areas, Restricted Use Areas, consolidated areas and the location of Legal Reserves.
Information	Questionnaire for the user to provide some specific information about the property. The user must answer each of the questions displayed in this questionnaire by selecting the "Yes" or "No" options. In some questions, if the answer option selected was "Yes", the system will display new additional fields that the user must fill in. For example, if the user answers "Yes" to the question "The rural property has an area with a deficit of native vegetation for the purposes of complying with the Legal Reserve", they must indicate in the following field which alternative they will adopt, alone or jointly, to regularize the deficit.

Source: Adapted by Vergili; Saliba (2023, p. 19) and User manual for the registration module – CAR (2023)

Vergili and Saliba (2023, p. 19) note that for information made available about the property itself to be considered personal data, it must be linked to a natural person. Thus, if a territory is linked to an Individual Taxpayer ID, personal data is processed in this situation and the General Data Protection Law (LGPD) is applicable. On the other hand, if the territory is linked to a company, the LGPD does not apply.

CAR and SICAR stand out as digital systems and should be analyzed broadly in terms of how government entities are using these solutions to achieve the Sustainable Development Goals (SDGs). India's chairmanship of the G20 defined digital

public infrastructures as a “set of shared, secure, interoperable digital systems. These systems should be able to be built on open norms and standards to deliver and provide equitable access to public and/or private services at scale” (G20. India’s G20 Chairmanship, 2023, p. 333).

In addition, the United Nations Secretary-General’s “High Impact Initiative on Digital Public Infrastructure”[34], highlighting how digital technologies can accelerate progress towards the Sustainable Development Goals (SDGs). At the event, Brazil’s Minister for Management and Innovation in Public Services, Esther Dweck, pointed out that the CAR is one of Brazil’s major digital public infrastructure initiatives. As such, it is important to understand how the CAR could fit into this definition. In the table below, we take up the points relating to each aspect of digital public infrastructure, as described in the playbook created by India’s G20 chairmanship, with the addition of a CAR column so that we can see how close it is to the definition of an DPI.

34 Action that was part of the SGD Digital Summit, promoted by the International Telecommunication Unit (ITU) and the United Nations Development Program (UNDP).

Table 4 - CAR as Digital Public Infrastructure

Terms	Contextualization	CAR
Infrastructure	Innovation enabler on a national scale: acts as a foundation for the large-scale development of digital solutions.	SICAR is a federal database platform that compiles the information registered and recorded in the CAR.
	Ecosystem-led implementation: DPI can be led by the private sector, led by the public-private sector or by the public sector.	It's a public sector-led implementation.
	Impact on the ecosystem: can be harnessed in the public and private spheres.	It has an impact both in the public domain and in the private sector on compliance with environmental legislation on rural properties.
Public	Public governance and accountability to people.	Created by specific legislation and managed through normative instructions, subject to public challenge and debate.
	Guided by the public interest.	Its purpose is environmental protection.
	Governmental orchestration.	Administered by the Brazilian federal executive branch.
Digital	Digital railways.	Enables data-based environmental decision-making.
	Enables remote, paperless, presence-less service delivery.	Remote access and registration, including public consultations.
	Reducing cost and increasing access through digital.	Although there are challenges in validating the data, the platform has been widely adhered to in the country.

According to the Rural Environmental Registry (CAR) report, in October 2023 the system had more than seven million rural properties registered, totaling more than 671 million hectares[35]. These figures show how there has been a change in how data is collected and how it can be monitored. According to Gonçalves (2022, p. 18):

35 See: https://www.car.gov.br/manuais/Boletim_Informativo_Outubro_de_2023.pdf. Accessed 16 Aug. 2024

> Implementing a registration stage in the CAR [Rural Environmental Registry] has transformed the reality and ways of monitoring native vegetation and approving legal reserve areas on rural properties, making it possible for the government to take unprecedented action in a country like Brazil, which has continental dimensions, regional particularities and areas that are difficult to access. (Gonçalves, 2022, p. 18)

The effective implementation of the CAR as a digital public infrastructure is vital, as it is an essential tool for environmental control and planning. However, the current reality shows that there are still challenges to the effective implementation of the tool as a DPI. The first issue is the low number of validations of registrations, resulting in a lack of environmental management. In addition, there is a problem of transparency, both in terms of the status of the registers in terms of the existence of illegal deforestation (data not provided for in the Forest Code), and the data of registered landowners (even when they are legal entities) which has been placed under wraps by the Ministry of the Environment's Normative Instruction No. 3/2014.

The absence of this data directly impacts the possibility of social control of the public administration, as well as preventing citizens from taking action in defense of their rights[36], especially the right to the environment and the original right to land, specific to indigenous peoples. In addition, it jeopardizes the very purpose of the CAR, since the computed data takes time to be validated and the lack of transparency makes it difficult to file complaints.

Furthermore, the lack of transparency in landowner data exacerbates the asymmetry that exists in the country. According to Vergili and Saliba (2023), while rural property owners have the option of keeping their data closed, beneficiaries of land reform programs have various personal data exposed as a way of ensuring transparency and enabling social control.

Additionally, other rights and principles are affected, such as the violation of dignity, freedom and physical integrity, especially of traditional peoples and groups whose lands are invaded; the violation of consumer rights, since it is not possible to ascertain whether the product is produced or extracted legally and without violating the Forest Code; and the violation of economic development and fair competition, since the lack of information hinders the identification and reporting of fraud and unfair practices, such as cattle laundering and the appropriation of land by means of gorged deeds (land grabbing) (Vergili; Saliba, 2023).

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36 The Brazilian Association of Members of the Public Prosecutor's Office for the Environment (ABRAMPA) has issued a technical note pointing out how CAR transparency issues affect social control in environmental policies. See: https://abrampa.org.br/file?url=/wp-content/uploads/2024/04/Nota_Tecnica_ABRAMPA_Transparencia_Dados_CAR_2023.pdf.

Evolving CAR as a public interest DPI, with a greater level of transparency, local ownership, and more interoperability with other policy areas and tools, could enable CAR to have more impact for fighting climate change as well as on social justice objectives, poverty reduction and inclusive economic growth. .

During the Common Horizons event organized by Data Privacy Brasil, participants from different sectors were invited to debate the topic of digital public infrastructure in various contexts, one of which was climate justice. In this debate, it was emphasized that one of the main benefits of using the CAR as a DPI was product traceability. The interoperability resulting from the digital infrastructure would make it possible to trace products back to the indirect supplier and cross-reference this data with deforestation alerts, a technology that has already been implemented using the CAR. This functionality favors sustainable development and reinforces the application of the Forest Code, and also strengthens the export market, given that traceability is an increasingly common requirement[37].

The research carried out semi-structured interviews with a range of experts to explore the topic of DPI and the use of data for initiatives to tackle climate change, aiming to identify possibilities for structuring a DPI for the environmental sphere. In this set of contributions, we would like to highlight the fact that governance is one of the most complicated points in the interviews. Thus, the adoption of a DPI, such as the CAR, must include transparent governance by the Brazilian federal government, where the interests of different parties are recognized and legitimized.

It was found that the concept of digital public infrastructure is generally perceived as the construction of an infrastructure for different actors, both public and private, to use and reuse. In this regard, CAR's potential as a DPI is, according to the interviews, to function as an environmental database in which it is possible to identify deforestation data, land use for livestock and subsidize land use monitoring actions. However, the declaratory format for including data in the CAR is a risk for its implementation as an environmental DPI, as its structure allows for information that is against the law, such as the registration of land in indigenous areas.

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37 One example is the European Union's regulation that, as of 1 January 2025, will bar imported products from areas that have been deforested. External influence is bringing greater attention to the Brazilian bovine meat traceability debate. For more information: https://oglobo.globo.com/blogs/miriam-leitao/post/2024/08/estudo-do-ipea-mostra-impacto-de-lei-antidesmatamento-da-ue-na-exportacao-brasileira-de-carne-e-soja.ghtml

The incorporation of the CAR as a DPI is a measure that encourages the processing of personal data in a way that is compatible with its purpose, unblocking bureaucratic processes, including for potential registrants. It is a way of strengthening environmental control and management and fostering economic and sustainable development, with the prospect, by means of an appropriate public policy, of including not only large landowners but also small rural producers on this agenda. However, its structure still requires development to improve governance and transparency of decisions made. Therefore, the dispute over the concept of 'public' in the infrastructure is essential, as it guarantees data quality and participatory governance, preventing its implementation from serving only as a call for innovation on behalf of the government.

Digital Public Goods in the Fight Against Climate Change

The fight against climate change requires initiatives and efforts around the world, as its impacts are felt to varying degrees in all countries. To this end, an open data framework is crucial, as it is an enabling strategy for developing effective and locally relevant solutions.

According to the definition described on the open definition[38] page: “Open data and content can be freely used, modified, and shared by anyone for any purpose”[39]. This aligns well with the DPG definition operationalized by the DPGA which indicates that that digital public goods are open source software, open standards, open data, open artificial intelligence (AI) models and collections of open content that respect privacy, laws, applicable good practices, do no harm and help achieve the Sustainable Development Goals (SDGs).

These open source approaches, which embed the use of open standards , contribute to building more transparent systems, enable greater interoperability between systems with more fluid data exchange and inhibit the logic of platformisation with the construction of closed silos. Environmental policies can benefit from this scenario by using this structure to monitor and improve their actions

Three initiatives that provide open data, one of the purposes of which can be to aid efforts to respond to climate change, will be discussed. The document “Call for Weather, Climate, & Hydrological information datasets to be made open and freely available as Digital Public Goods” portrays the importance of data openness within digital public goods emphasizing that data should be ‘available to others and can be freely used, reused, republished and redistributed by anyone’ e-published and redistributed by anyone” (DPGA; ITU; WMO, 2022, p. 9).

The fight against climate change is envisioned through various actions, including making data available, which can help improve systems and software that require data in addition to the sharing of solutions that can be replicated to develop new initiatives. As a central aspect, we emphasize the importance of transparency, interoperability and open data. There are over 160 digital public goods recognized by and listed on the DPG Registry. The projects CKAN[40], Hand-in-Hand Geospa-

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38 Open Definition. Defining Open in Open Data, Open Content and Open Knowledge. Available at: https://opendefinition.org/. Accessed on: 10 September 2024.

39 Open Definition. Defining Open in Open Data, Open Content and Open Knowledge. Available at: https://opendefinition.org/. Accessed on: 10 September 2024.

40 Digital Public Goods Alliance. CKAN. General information. Available at: https://app.digitalpublicgoods.net/a/11476. Accessed on: 10 September 2024.

tial Platform[41], Sentinel[42] registered as digital public goods and MapBiomas[43] (a Brazilian collaborative network that has several enabling characteristics of a DPG) represent open solutions that make their data available for use, modification and sharing.

We'll start with CKAN, whose function is to facilitate the publication, sharing and use of data and which, according to its website, is "The world's leading open source data management system"[44]. An example of its use is the Brazilian government's dados.gov.br portal[45]. The large volume of public data generated, especially since the Access to Information Act[46], is managed by the portal, which uses CKAN as the enabling technology to make the data available.

Since 2023, CKAN has been officially recognized as a DPG and its functionalities have been expanded, in addition to the recognition that its work actively contributes to nine of the seventeen SDGs. As a result, CKAN is an open source technological solution that enables the management and availability of open data "underlining its significant role in global problem-solving and commitment to the advancement of society through open data" (CKAN, 2024[47]). CKAN is already being utilized for environmental datasets[48], and as an open-source data management system, it offers transparent access to information, supporting more informed decision-making.

The Hand-in-Hand Geospatial Platform and Sentinel-2 10m Land Use/Land Cover dataset are two solutions recognized as digital public goods by the DPGA under the category of open data. Hand-in-Hand is managed by the Food and Agriculture Organization of the United Nations (FAO), a specialised UN agency and existing DPGA member that leads international efforts to overcome hunger, and the initiative is a structured tool to improve the effectiveness of interventions in agriculture and rural development, promoting transparency and the efficient use of data to achieve the SDGs. The initiative works by modeling and analyzing geospatial data in order to map opportunities to increase incomes and reduce both

41 Food and Agriculture Organization of the United States. Hand-in-Hand Geospatial Platform. Available at: https://www.fao.org/hih-geospatial-platform/en/. Accessed on: 10 September 2024.

42 Sentinel-2 10m Land Use/Land Cover Time Series. Available at: https://www.arcgis.com/home/item.html?id=cf-cb7609de5f478eb7666240902d4d3d. Accessed on: 10 September 2024.

43 MAPBIOMAS BRAZIL. Frequently asked questions. Available at: https://brasil.mapbiomas.org. Acesso em: 14 ago. 2024.

44 CKAN. Available at: https://ckan.org/. Accessed on: 10 September 2024.

45 CKAN. Using CKAN: building a Brazilian government data portal. Available at: https://ckan.org/blog/ckan-brazil. Accessed on: 24 October 2024.

46 Law No. 12.527/2011. Available at: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/lei/l12527.htm. Accessed on: 10 September 2024.

47 CKAN. CKAN is now a Digital Public Goods. Available at: https://ckan.org/blog/ckan-is-now-a-digital-public-good. Accessed on: 10 September 2024.

48 Some examples are CanWIN, that helps address key water quality issues, and the Environment and Climate Change Canada, with statistics of wind and waves.

inequalities and vulnerabilities among rural populations. Its website[49] highlights that the project is a digital public good that helps analyze and compare data on food and agriculture, subsidizing more assertive interventions to reduce poverty and hunger, as well as to increase economic development.

Sentinel-2 10m Land Use/Land Cover dataset is also a recognized DPG and is used to visualize and analyze global geospatial data on land use/cover. Its work supports initiatives and efforts focused on food security and environmental monitoring. The website highlights that "each year is generated with Impact Observatory's deep learning AI land classification model, trained using billions of human-labeled image pixels from the National Geographic Society"[50]. This DPG provides public access to global land use and land cover data from 2017 to 2022 at a resolution of 10 meters. The global mapping of agricultural land and land use conversions helps to achieve a number of the Sustainable Development Goals (SDGs), as it makes it possible to increase food security, monitor urban areas and green spaces. Furthermore, it enables us to understand the impact of changes in land cover on CO2 emissions and climate resilience.

These examples provide an overview of the capacity of DPGs for progress towards the Sustainable Development Goals (SDGs) and the fight against climate change. Their use can favor different states, civil society and relevant actors. We emphasize the centrality of basic aspects of SDGs such as open data, transparency, interoperability and ease of adoption in different situations. Previous experiences can serve as inspiration for the CAR: by proposing the use of DPGs from its inception, the principles underlying these technologies point to greater social oversight and innovation. Additionally, it ensures the necessary adaptability for the solution's scalability, enabling the creation of new functionalities based on the needs driven by the service's digitalization and interoperability.

The final example is the Annual Mapping of Land Cover in Brazil Project (MapBiomas)[51], an initiative of the Climate Observatory that was co-created and is developed by a multi-institutional network comprising universities, NGOs and private technology companies, with the aim of annually mapping both land cover and land use in Brazil, as well as monitoring water surface, fire scars, changes in the territory and producing reports for each deforestation event detected in Brazil.

It is structured as a digital platform for monitoring changes in land use. Its activities focus on the annual monitoring of deforestation in all of the country's biomes. The development and availability of studies and research on different biomes by

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49 Food and Agriculture Organization of the United States. Hand-in-Hand Geospatial Platform Available at: https://www.fao.org/hih-geospatial-platform/about/en. Accessed on: 10 September 2024

50 ArcGIS. Sentinel-2 10m Land Use/Land Cover Time Series. Available at: https://www.arcgis.com/home/item.html?id=cfcb7609de5f478eb7666240902d4d3d. Accessed on: 10 September 2024.

51 MAPBIOMAS. Available at: https://brasil.mapbiomas.org/perguntas-frequentes/. Accessed on: 10 September 2024.

MapBiomas helps to analyze and make decisions for public bodies, private and social entities. The project even uses data from Sentinel-2, the DPG presented earlier, to make one of the maps in its collection, the MapBiomas 10 meters beta with annual maps of land cover and land use.

This set of maps allows for an understanding of how land use has changed over time, the impact of these changes on Brazilian biomes, their contribution to greenhouse gas emissions and the consequences for climate change. Making this data available is a source that can help design and improve public policies and provide input for analyzing impacts on the environment and developing actions to protect the land. The project makes its data available under the Creative Commons CC-BY-SA license, which means it is public, open and free and can even be used for commercial purposes.

Although it has not yet been nominated as a DPG and verified to meet the DPG standard,MapBiomas already meets important criteria for open source and brings benefits to a high number of stakeholders. Its visibility, adoption and thereby relevance would likely grow even further if it were to become a DPG listed on the DPG registry.

The examples above demonstrate how digital public goods can favor the advancement of the SDGs, using robust methodologies and transparent digital approaches. They exemplify how technologies can promote the fight against climate change, bringing together actors from civil society, academia, governments and companies.

Digital public infrastructure and digital public goods for global cooperation

Digital public infrastructure and digital public goods have the capacity to become an indispensable element for sustainable development and social progress, and this explains their prominent place in the international digitalisation discourse and the Global Digital Compact. Due to their open and interoperable structure, the sharing of experiences from different existing implementation cases provide means to accelerate new initiatives. Reflecting this trend, events on the topics of DPI and DPGs are happening with increased frequency and with high interest in participation from different regions, creating and strengthening bridges between participating countries.

A recent and decisive milestone in this movement has been the series of events part of the United Nations General Assembly week, including the Summit of the Future, which took place in New York city in September, 2024, and which brought the enactment of the UN's Global Digital Compact, an annex to the Pact of the Future which recognized the importance of both DPGs and DPI for digital transformation and innovation. The Secretary General Envoy on Technology, Amandeep Singh Gill, took that opportunity to summarize[52] the move of DPI in the international agenda as an understanding originally built between 20 nations (referring to the G20 Indian presidency) being spiraled into an understanding across 193 nations (UN member-states). We will highlight two particular events in that context: "50-in-5: Digital Public Infrastructure for People and Planet"[53] and the Global Summit on Digital Public Infrastructure[54].

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52 https://www.ipinst.org/2024/09/digital-public-infrastructure-whats-next-after-the-global-digital-compact#6. Accessed on: 07 October 2024.

53 https://50in5.net/dpi4peopleandplanet/. Accessed on: 24 September 2024.

54 https://www.globaldpisummit.org/. Accessed on: 24 September 2024.

The “50-in-5”[55] initiative was launched in November 2023. Its goal is to accelerate the development of DPI in 50 countries by 2028, assisting in the design, launch, and scaling of components of their digital public infrastructure in a secure, inclusive, and interoperable manner. On September 23rd 2024, at the event “50-in-5: Digital Public Infrastructure for People and the Planet”, six more countries joined the campaign: Brazil, Cambodia, France, Nigeria, Ukraine, and Uruguay. Thus, after less than a year, the campaign includes 22 countries from different continents and income levels[56].

The central focus of the campaign is to connect countries to accelerate the implementation of DPI based on their common goals and challenges, such as digital inclusion, privacy, and information security. The 50-in-5 event on September 23rd highlighted the potential of digital public goods for enabling faster and better DPI implementation, with multiple references to using and sharing DPGs from the countries participating on stage at the event[57].

It is worth highlighting Brazil’s participation in the event, represented by Esther Dweck, Minister of Management and Innovation in Public Services. In joining the 50-in-5 campaign, she emphasized the Rural Environmental Registry as a tool to promote sustainability in rural areas. The Minister also noted that the registry will play a significant role at COP30 in Belém in 2025[58], highlighting how Brazil has supported the agenda for an inclusive, accessible, human-centered digital transformation that combats climate change.

In this context, the construction of digital public infrastructure provides pathways for greater transparency and effectiveness in government action. Moreover, the use of digital public goods brings open innovation, interoperability, and ability for countries to enhance digital cooperation through the sharing of technologies.

Another example to be highlighted is the Global Summit on Digital Public Infrastructure, held for the first time in October 2024 in Cairo, Egypt. Its objective was to stimulate the sharing of experiences in adopting DPI to achieve the Sustainable Development Goals with representatives from around the world. The event aimed to provide a comprehensive overview of the broad possibilities of using DPI, emphasizing its capacity to integrate innovative technologies into political frameworks, enabling implementation models that reshape public infrastructure.

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55 https://50in5.net/. Accessed on: 24 September 2024.

56 See here the map with countries that joined the campaign: <https://50in5.net/#map>.

57 Brazil, Cambodia, the Dominican Republic, Estonia, France, Lesotho, Malawi, Nigeria, Norway, Sierra Leone, Singapore, Sri Lanka, Togo, Ukraine, and Zambia.

58 https://www.gov.br/gestao/pt-br/assuntos/noticias/2024/setembro/brasil-adere-a-iniciativa-da-onu-que-promove-o-uso-da-infraestrutura-publica-digital-em-beneficio-das-pessoas-e-do-planeta. Accessed on: 24 September 2024.

These events are intrinsically connected to the topics addressed in this report, as they are designed as spaces for the exchange of knowledge, challenges, and opportunities regarding the implementation of Digital Public Infrastructure (DPI). At a time when technology enables faster access to information, sharing the various actions of countries in developing and implementing digital public infrastructure with the support of digital public goods is central to accelerating the journeys toward achieving DPI. These exchanges about practices and technologies used in the journey help reduce costs, build local capacities, maximize impacts, and effectively shorten the implementation of DPI. For Brazil this is critical for building DPI that truly serves the public interest, and it will have direct relevance for achieving priority objectives such as addressing climate change and for integrating environmental objectives into other policy areas.

Concluding Remarks

This report discusses the concepts of digital public infrastructure and digital public goods, highlighting their ability to contribute to the fight against climate change and the promotion of a more sustainable future. It is understood that both DPI and DPGs are important in the Brazilian and global context, and that a collaborative and inclusive approach is needed to debate these concepts and develop tools.

In 2018, the United Nations made an effort to discuss measures and proposals to advance and strengthen cooperation in the digital space between Governments, the private sector, civil society and other stakeholders at the High Level Panel on Digital Co-operation[59]. As a result, the report "The Age of Digital Interdependence"[60] was produced with recommendations to help optimize the use of digital technologies and mitigate the risks of their use.

In this context, the Digital Public Goods Alliance (DPGA) was created, focusing on recommendation 1B of the aforementioned report. Given the multiplicity of actors and debates, the DPGA has emerged as a platform to share, operationalize and centralize the registration of digital public goods and gather data sets while respecting privacy. Composed of a broad multi-stakeholder alliance involving the United Nations, its aim is to coordinate and exploit synergies between stakeholders around digital public goods.

Building robust DPIs, based on open technology and effective governance, contributes to ensuring that everyone has equitable access to essential services, promoting inclusion and innovation. In addition, DPGs as open source tools, offer valuable opportunities to strengthen these infrastructures, enabling governments and organizations to adopt solutions that meet society's needs in an efficient and sustainable way. Practical examples, such as the Modular Open Source Identity Platform (MOSIP)[61] he MET Norway Weather API[62], illustrate how DPGs can be used to tackle contemporary challenges such as climate change.

By combining its inspiring environmental and digital transformation agendas and by using the G20 and COP30 as global platforms, Brazil has a unique opportunity to influence the global agenda and promote practices that integrate technology

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59 UNITED NATIONS. Guterres announces creation of high-level panel on digital co-operation. Available at: https://news.un.org/pt/story/2018/07/1630891. Accessed on 13 September 2024.

60 Digital Cooperation. The Ages of Digital Independence. Report of the UN Secretary-General's High-Level Panel on Digital Cooperation. 2019. Available at: https://www.un.org/en/pdfs/HLP%20on%20Digital%20Cooperation%20Report%20Executive%20Summary%20-%20ENG.pdf. Accessed on: 28 July 2024.

61 MOSIP. Empowering Lives One Unique ID at a Time. Available at: https://www.mosip.io. Accessed on: 30 August 2024.

62 MET Weather API. Available at: https://api.met.no/. Accessed on: 30 August 2024.

and public policies in favor of social and environmental well-being. Thus, multi-sectoral collaboration and the active participation of different stakeholders are crucial to the success of these initiatives, ensuring that digitalization not only boosts Government efficiency, but also respects and promotes human rights and social justice. Ultimately, the integration of DPIs and DPGs represents a promising path towards combating climate change with actions that enable a more sustainable and equitable future.

Brazil's central position in shaping the global debate on climate change by incorporating digital tools such as DPI and DPGs is reinforced, particularly given its previous experience in developing and implementing tools such as PIX, DREX, for financial digitalization, and Gov.br, with a focus on digital identity.

From a financial standpoint, PIX is a successful global benchmark as an instant payment system. Its public digital infrastructure was developed and is operated by the Central Bank of Brazil (BCB), and improvements to the system continue to be implemented. For example, following the approval of a new foreign exchange law in Brazil, the BCB is moving towards the implementation of the international PIX[63] which will allow accounts in other countries to make instant payments. Gov.br, in turn, is a platform where information can be accessed, public services can be requested and your account can be used for validation in different instances and government bodies. The combination of experience and innovation in Brazil's DPIs suggests promising pathways for transnational environmental monitoring, sustainability, product traceability, and more..

As part of this research we interviewed experts in the environmental field and on digital public infrastructure who emphasized the role of the CAR as a database that makes it possible to provide central information for fighting deforestation. The timing makes it possible for the Brazilian experience to serve as a basis for digital public infrastructure, such as the CAR, to be combined with digital public goods, such as MapBiomas, expanding their impact with a focus on the SDGs.

We introduced and conceptualized both digital public infrastructure and digital public goods, as their creation, adoption and implementation have positive aspects for the countries that choose to incorporate them. We emphasize the possibility of developing digital solutions at lower costs, since the premise of open applications makes it possible to reuse and adapt them to different contexts. The CAR as a digital public infrastructure and MapBiomas as a potential digital public good complement each other by producing data that strengthens national sovereignty, the development of public policies aimed at combating deforestation and generating public value for Brazilian society and environmental preservation worldwide.

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63 OLHAR DIGITAL. International Pix: payment is now accepted in several countries; see which ones. https://olhardigital.com.br/2024/07/07/pro/pix-internacional-pagamento-ja-e-aceito-em-varios-paises-veja-quais/. Accessed on: 30 Aug. 2024.

The consolidation of these technologies as DPI and DPG will facilitate reuse and adaptation both nationally and internationally.

However, it is necessary to bear in mind the risks associated with such tools, so the implementation of these technologies must be concerned with technical aspects but must also have solid and inclusive governance so that possible power asymmetries can be resolved. It is therefore essential that the solutions developed have both privacy and security as standards and are built to maximize the public interest.

The timing of Brazil's hosting of the COP30 in 2025 and the chairmanship of the G20 in 2024 allows for the continuation of India's mandate, in particular the transformation of the Rural Environmental Registry (CAR) into an DPI. These experiences can serve as an example for other States and interested parties in building an agenda focused on combating climate change using open digital technologies, with robust data governance that promotes transparency and public participation.

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